Pest Management Regulatory Agency
Agence de réglementation de la lutte antiparasitaire

Regulatory Proposal

PRO2003-01

Estimating the Water Component of a Dietary Exposure Assessment

This document provides an overview of the Pest Management Regulatory Agency's policy in estimating the concentration of pesticides in water sources. These estimates are then incorporated into aggregate exposure assessments as part of the process of assessing the potential impact of pesticide use on the health of Canadians. The types of models being used by the Agency and the scenario-based inputs for these models are described. In addition, the importance of monitoring data and water treatment is discussed.

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Executive Summary

The Pest Management Regulatory Agency (PMRA) is estimating the concentration of pesticides in potential drinking water sources and incorporating these estimates into aggregate exposure assessments as part of the process of assessing the potential impact of pesticide use on the health of Canadians.

Canadians use surface water as well as groundwater for drinking, consequently the Agency estimates pesticide concentrations in both these drinking water sources. For surface water, the PMRA uses the linked Pesticide Root Zone Model (PRZM) and the Exposure Analysis Modelling System (EXAMS) to model pesticide concentrations. Pesticide concentrations in surface water are modelled in two vulnerable drinking water sources. The first, an index reservoir, is based on the dimensions of the Shipman reservoir which is used by the United States Environmental Protection Agency (U.S. EPA) in its exposure assessments. The second source is a prairie dugout and will only be used when pesticides are to be registered in the prairie provinces where dugouts are common. Pesticide concentrations in groundwater are modelled using the Leaching Estimation And Chemistry Model (LEACHM). LEACHM is used to estimate pesticide concentrations in shallow groundwater where concentrations are likely to be higher than the deeper groundwater typically used for drinking water.

For both surface water and groundwater modelling, the PMRA has developed a series of agricultural scenarios which are typical of many of the major crop growing areas in Canada. Inputs for these scenarios include realistic data on the weather, soil, crops and hydrology.

Estimating pesticide concentrations in drinking water sources is a tiered process consisting of progressive levels. Initial levels are conservative and represent upper bound estimates of pesticide concentrations. If these initial estimates do not result in unacceptable exposure, then no further estimates are required. If initial levels result in an unacceptable exposure estimate, then a more resource intensive higher level estimate is generated.

In addition to modelling, the Agency considers available pesticide monitoring data as part of the process of estimating pesticide concentrations in drinking water sources. Unfortunately, there is a paucity of adequate monitoring data in Canada, and the Agency is pursuing opportunities to develop high quality national scale monitoring data with the provinces, territories, municipalities as well as other federal departments.

The process of estimating pesticide concentrations in drinking water sources is evolving. At the present time, the Agency is formalising the Level 1 screening assessment. A formalised approach for higher levels or refined assessments has yet to be completed. In the interim, refined assessments will be conducted on a case-by-case basis drawing on the expertise of Agency modellers, experts in the field of environmental fate and chemistry, as well as experts in the field of human exposure and toxicology.

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1.0 Introduction

Under the *Pest Control Products Act* (PCPA), the PMRA has the responsibility to protect Canadians from the risks associated with pesticide use. In order to assess potential risks of pesticide use to the health of Canadians, the Agency must be able to estimate their potential exposure to pesticides and any pesticide breakdown products that might be of toxicological concern. The exposure assessment must be comprehensive and must include pesticide exposure from all sources and by all routes of exposure. The exposure to pesticide residues in sources of drinking water is an important part of the dietary exposure assessment.

Pesticides are widely used throughout Canada and there are many potential pathways via which they may find their way into drinking water sources. In Canada, both surface waters and ground water are used as sources of drinking water, and pesticide use patterns are such that contamination of these sources may occur via drift, runoff or leaching through the soil.

In the past, the PMRA incorporated estimates of pesticide concentrations in surface waters in dietary risk assessments by using conservative assumptions that often resulted in high and unrealistic exposure estimates. The PMRA is now in the process of developing a more comprehensive and refined approach to estimating the concentration of these compounds in drinking water sources. An overview of this new, standardized approach is described in this document. It is consistent with a similar approach being taken by the U.S. EPA.

2.0 Current approaches in other jurisdictions

Both the United States as well as the European Union (EU) estimate pesticide concentrations in surface and groundwater as part of their risk assessment process (FOCUS 1995, FOCUS 1997, FOCUS 2000, U.S. EPA Office of Pesticide Programs 1999). Their respective approaches were developed in co-operation and consultation with experts from government, industry and academia. In the case of the U.S., EECs are estimated and aggregated along with estimates of food exposure and occupational exposure to produce an aggregate risk assessment. In the case of the European Union, the EECs are not incorporated into an aggregate assessment. Instead, they are compared with the legislated maximum allowable concentrations in drinking water sources that “can be consumed safely on a life-long basis” (Council Directive 98/83/1998, 1998).

Both these jurisdictions use a tiered approach to estimate pesticide concentrations in drinking water sources. Initial tiers consist of using screening level models with conservative inputs to rapidly screen out pesticides which will probably not pose a concern with respect to drinking water. At the initial screening level assessment, the U.S. EPA uses models which simulate generic conservative scenarios to determine EECs in groundwater and surface water. If a concern is identified with surface water, then a more in-depth (Tier 2) screening level analysis is conducted using a more robust model with regional agricultural scenarios. The U.S. EPA does not currently conduct Tier 2 modelling when groundwater concerns are identified but instead requests monitoring studies. In contrast, the EU conducts groundwater modelling using robust models with regional agricultural scenarios at the outset of their analysis.

If pesticides fail to pass these initial screening levels, a higher tier analysis is necessary. Higher tiers of assessment may include the use of more refined modelling techniques, using available monitoring data, and may require that additional laboratory and/or field studies be conducted by the registrant. The rationale behind this approach is that the initial tiers are less resource-intensive and therefore allow “safe”chemicals to be identified and screened out with a minimal input of resources (both monetary and human). Currently, most jurisdictions only have a formal process for screening level analysis.

3.0 Proposed PMRA approach for estimating drinking water concentrations

Close to 75% of Canadians receive their drinking water exclusively from surface water sources, the remaining 25% receive their water either exclusively from groundwater or as a combination of groundwater and surface water (Fig.1). Consequently, it is essential to estimate pesticide concentrations in groundwater as well as surface water sources in order to adequately reflect the potential for pesticide exposure via drinking water in Canada. Therefore, the PMRA is estimating pesticide concentrations in both surface and groundwater sources using a multi-levelled approach similar to the tiered approach followed by the U.S. and the EU.

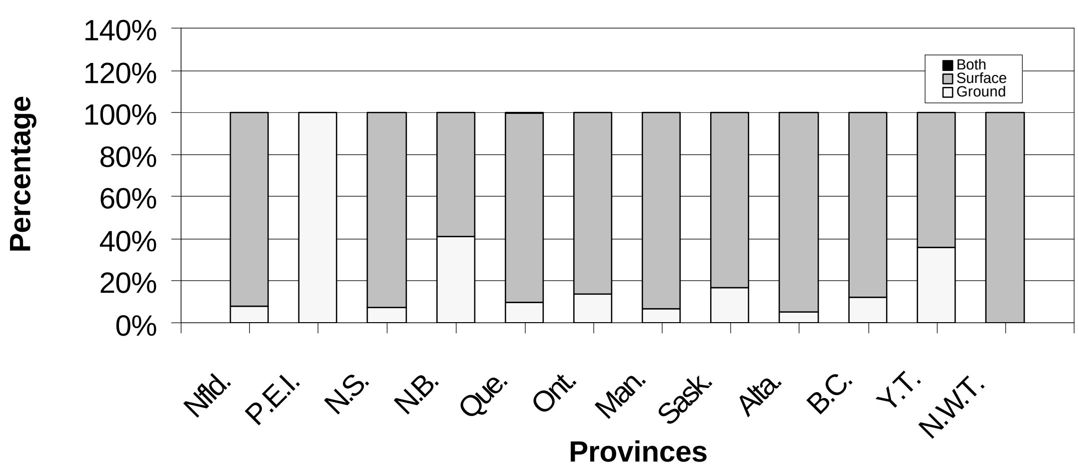

Figure 1. Percentage of water from ground or surface water sources supplied to residents of Canadian municipalities with populations exceeding 1000 (generated from the 1999 Environment Canada Municipal Water Use Database)

The PMRA uses established mechanistic models to estimate pesticide concentrations in both surface and groundwater sources of drinking water. Many of the key input parameters for the models consist of real world data obtained from experimental studies (physical and chemical properties of the pesticide in question), Canadian weather stations (site specific rainfall and temperature data), Canadian soil maps (site specific soil profiles), and the product's label (application rates and frequencies).

The initial screening level estimate, Level 1, is used to screen out those chemicals which are unlikely to pose a significant risk to drinking water sources. These Level 1 estimates use conservative inputs including:

- **Characteristics of the product**
  - a. Longest half-lives[1] in environmental media, e.g., soil, water
  - b. Lowest K_{oc} values[2]
- **Assumptions about use**
  - a. Highest label rate of application
  - b. Maximum number of applications per year
  - c. Shortest interval between applications
  - d. The pesticide is applied every year of the simulation
  - e. 100% of the watershed assumed to be cropped
  - f. 100% of the crops assumed to be treated with pesticide

In addition, the model is run using one or more agricultural scenarios that reflect Canadian conditions. It is unlikely that pesticide concentrations in sources of drinking water will be as high as the EECs estimated in a Level 1 analysis when a pesticide is applied according to label directions.

As is the case with the U.S. EPA and the EU, a Level 1 estimate resulting in unacceptable pesticide concentrations in sources of drinking water must advance to a more refined, higher level assessment. The PMRA will refine Level 1 estimates using more realistic input parameters with the models such as typical use rates and use frequency. The use of monitoring data may also be used to refine Level 1 estimates. Additional studies may be required from the registrant[3].

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[1] Half-life refers to the amount of time it takes for 50% of the pesticide to break down in the environment.

[2] K_{oc} is a measure of the chemical mass that partitions to both the solid (organic carbon) and liquid phases. It is used to predict chemical partitioning and to estimate retardation.

[3] Estimates of occupational exposure as well as estimates of dietary exposure from food only will usually have been refined as much as possible prior to refining the estimates of EECs in water.

3.1 Agricultural scenarios

The PMRA is currently running its water models using a series of agricultural scenarios that were selected to reflect areas of major agricultural activity and the important crops grown in these selected areas. The scenarios were developed by Environment Canada as part of an Expert system for Pesticide Regulatory Evaluation Simulations (EXPRES) (Mutch et al., 1993). Each scenario within the database contains detailed information on soil properties (chemical, physical and hydrological), on crop parameters, agricultural practices, as well as detailed daily weather information from Canadian weather stations relevant to each of the scenarios.

The PMRA has developed 11 scenarios in its screening level assessment. A further 12 scenarios are available through EXPRES and are being considered for inclusion in this process. Additional scenarios not included in the EXPRES database may be developed to create a more comprehensive representation of agriculture and pesticide use patterns across the country. If necessary, the Agency will also add new scenarios and update existing ones on an ongoing basis in order to ensure that the scenarios remain current with respect to agricultural practices and weather patterns in Canada. Any new scenarios being considered will undergo a thorough scientific review prior to being adopted.

Agricultural scenarios that are currently being used by the Agency for Screening Level Estimates of pesticide concentrations in drinking water sources represent a variety of geographical, climatic and soil situations. They include scenarios representative of: the lower Fraser River valley, B.C. (raspberry), the Okanagan Valley, B.C. (orchard), the Peace River district of Alberta (barley), southern Alberta (sugar beet), southern Saskatchewan (wheat), Manitoba (potato), southwestern Ontario (corn), the Niagara region of Ontario (vineyard), the Yamaska river valley of Quebec (corn), Prince Edward Island (potato), and the Annapolis valley of Nova Scotia (apple).

For a Level 1 estimate, those scenarios that typically generate the most conservative (highest) estimates of EECs are used. If a pesticide's estimated concentration in drinking water sources exceeds acceptable levels and requires a refined estimate, then a scenario which more closely matches the actual use pattern of the pesticide will be used.

3.2 Surface water

3.2.1 Choice of surface water model

The PMRA uses the linked PRZM and the EXAMS to model surface water concentrations at all levels of its drinking water assessment. PRZM-EXAMS was developed by the U.S. EPA and has been used for several years in North-America and Europe. One of the reasons for the selection of these models is that they will account for the various factors affecting the surface runoff from the field, and the transformation and partitioning occurring in the water body. In addition, these models are capable of estimating EECs for both reservoirs and dugouts using Canadian soil, crop and weather information. With the recent advancements in processing speed of microcomputers, these models can be used to simulate multiple years.

The PRZM component of the model is used to predict the pesticide concentration dissolved in runoff waters and carried on entrained soil particles that will move from the field where the pesticide has been applied into a surface water body that is adjacent to the treated field. Input parameters include the characteristics of the pesticide (physico-chemical properties, transformation half-lives and mobility data), crop growth information, site specific information (soil properties, local topography and agricultural practices), and weather data. The FIFRA Environmental Model Validation Task Force concluded that PRZM simulations conducted using realistic input parameters generated results within an order of magnitude of the measured data (Jones, 2001).

The EXAMS component of the model is used to simulate environmental fate and transport processes of a pesticide once it enters a body of water. Such processes would include volatilization, sorption, hydrolysis, bio-transformation, and photolysis of the pesticide. Input parameters include the characteristics of the pesticide (physico-chemical properties, transformation half-lives and mobility data), limnological and physical characteristics of the water body, and weather data.

PRZM-EXAMS simulations are run for multiple years and can generate output in a variety of formats. Currently the PMRA is reporting the one-in-ten year (90th percentile) value of the yearly maxima of daily concentrations as well as the 90th percentile value of the average yearly concentration for use in its dietary exposure assessment.

As already indicated, an unacceptable Level 1 estimate would trigger a higher level of refinement. This will make use of refined modelling which could involve input parameters that are less conservative and scenarios that more accurately reflect the physical and chemical properties of the pesticide as well as its use pattern. The higher levels of refinement would also make use of available surface water monitoring data. If none are available, the registrant may be requested to conduct surface water monitoring studies.

3.2.2 Choice of receiving water body

Typical surface drinking water sources include natural water bodies such as rivers and lakes, as well as constructed water bodies such as reservoirs and dugouts. The choice of an appropriate receiving water body for use with surface water models hinges on what surface drinking water sources are considered to be vulnerable to pesticide contamination in Canada. Vulnerability depends on a combination of factors relating to pesticide usage, site/environmental factors, crop and pest management, and weather patterns (U.S. EPA, 1999). For instance, a small water body in an area with high run-off potential in combination with a high pesticide use rate may be more vulnerable than a large body of water in an area that does not favour run-off and has a low pesticide use rate.

In estimating pesticide concentrations in surface drinking water sources, two hydrometric scenarios are currently used: (1) a reservoir scenario, representative of a water supply from smaller municipalities, and (2) a farm dugout scenario typical of the Canadian prairies. These two hydrometric scenarios are considered to be particularly vulnerable because of their potential for contamination from local agricultural practices. Other scenarios may be added at a later date as the need arises but for the present the focus will be on these two scenarios.

In 1998, the U.S. EPA compiled a list of 82 candidate reservoirs and from that list selected the Shipman Reservoir (Illinois) as their index drinking water reservoir for modelling. This was because it was representative of a number of reservoirs in the central mid-western U.S. which were vulnerable to pesticide contamination and because appropriate pesticide monitoring data from the reservoir were available (U.S. EPA, 1999). A U.S. EPA monitoring program[4] ranked the Shipman Reservoir 8^{th} in terms of atrazine concentrations out of 175 surface water sites indicating that the index reservoir approach does represent a high exposure scenario for surface water. Following the U.S. rationale, the PMRA undertook a review of the Municipal Utility Database (MUD) (Environment Canada, 1999) to identify municipal water sources that were located in some of the major agricultural areas in Canada (Ontario, Manitoba, Saskatchewan and Alberta). Water sources were evaluated using three criteria which were deemed to be essential qualifications for a candidate reservoir:

(1) The reservoir capacity must be readily comparable to the Shipman reservoir.
(2) The reservoir or lake must be located within an area where agriculture is prevalent.
(3) The reservoir must have a monitoring program and a history of pesticide detections.

After an extensive search it was determined that there were no candidate reservoirs which met all three of the above criteria. As the Shipman reservoir has all the required physical information to be useful in the model, the PMRA has adopted the dimensions of the Shipman reservoir (surface area and drainage area) for use with PRZM–EXAMS. The use of the Shipman reservoir is considered to be an interim solution while a more representative Canadian reservoir is sought. It is felt that this interim solution is acceptable because, apart from the reservoir dimensions, other site specific information such as weather, soil, crop, and hydrological data are Canadian in origin and representative of the Canadian area being modelled and not of Shipman, Illinois.

The PMRA has also decided to include prairie dugouts as a second vulnerable surface drinking water source in Canada. This decision was taken because dugouts are used throughout the prairies as a household water supply, including drinking water, and because most dugouts tend to be in close proximity to pesticide-treated fields (Fred Martin, pers. comm.). Consequently, the PMRA has developed a prairie dugout

[4] These sites included reservoirs, lakes, and flowing water (U.S. EPA Office of Pesticide Programs, 1999)

scenario for use in estimating drinking water concentrations of pesticides that are used in the prairie provinces. The Agency is also actively pursuing opportunities aimed at improving the available data in order to adequately characterise prairie farm dugouts with respect to potential pesticide contamination.

Rivers and streams also constitute potential drinking water sources that may be vulnerable to pesticide contamination. However, as mentioned previously, the index reservoir is considered a high exposure scenario for surface water in general. As such, the PMRA is not planning to develop separate scenarios for rivers or streams as sources of drinking water.

The PMRA recognizes that at some locations, actual pesticide concentrations in surface water can be lower than the model estimates. This is especially true of the initial screening levels as the input parameters used for modelling are often conservative. In addition, although users could apply a pesticide at the highest rate and frequency allowed on a product label, typical use rates and frequencies are often lower than the values used in the model. Moreover, while not required by the pesticide label, users may engage in practices which may reduce pesticide runoff, such as soil-incorporation of the pesticide or the use of “no-application” zones or filter strips around water bodies. Thus, where typical application practices are lower than label maximum, where runoff prevention practices are widespread, or where soil properties and site characteristics are less conducive to runoff, actual concentrations in surface water may be lower than the values for the sites and conditions modelled.

3.3 Groundwater

3.3.1 Choice of groundwater model

The PMRA evaluated the suitability of MACRO, LEACHM, SCI-GROW, PESTAN, and PRZM/VADOFT for use as groundwater models. There were four basic requirements for a groundwater model:

- the model’s programming must be able to be modified if necessary;
- the model must be able to evaluate different environmental conditions (i.e., climate and soil);
- the model’s input requirements should be similar to the data already being submitted to the Agency;
- the model must be user-friendly.

Of the models considered, only LEACHM was found to meet all four requirements, consequently, the PMRA decided to use LEACHM to model ground water concentrations at all levels of its drinking water estimates.

LEACHM is a suite of models that simulate the movement and fate of water and chemicals within soil profiles. It was developed in 1984 and has been subject to numerous extensions and revisions since that time (Hutson, 2001).

LEACHP is the model within the LEACHM suite which simulates pesticide fate and transport in soils as well as pesticide uptake into plants. As with PRZM–EXAMS, input parameters for LEACHP include pesticide specific chemistry, environmental fate and transport data as well as site specific information including crop specific data, soil properties, and pesticide use patterns. The model simulates pesticide and water movement in soil over the course of one or more growing seasons. The model's output is extensive but includes estimates of pesticide concentrations at various depths within the soil profile as well as estimated fluxes of pesticide and water across specified boundaries within the soil profile.

Attempts were made to obtain a data set that was sufficient to test the LEACHP model. Results of an internal review indicated that a Canadian-based data set probably does not exist. Although several other published international studies have since been identified, only one pesticide leaching study (Boesten and van der Pas, 1999) was sufficient in meeting the data requirements of LEACHP. A validation exercise using this data set was undertaken and the results indicate that LEACHP performed well in predicting both the movement and quantity of pesticide in the soil profile.

As with the surface models, if the estimated groundwater concentration generated using the Level 1 assumptions results in unacceptable risk, a higher level of refinement will be triggered. The higher levels of refinement may use refined modelling with more realistic input parameters as well as scenarios that more accurately reflect actual use patterns. Valid groundwater monitoring data will also be used where available and if none is available the registrant may be requested to conduct groundwater monitoring studies.

3.3.2 Proposed approach for calculating EECs in groundwater

As with surface water, it is important to estimate EECs in groundwater that is considered to be vulnerable to pesticide contamination. Two approaches to calculating EECs in groundwater are being considered by the PMRA. Both are based on the assumption that the water present near the top of the water table is more vulnerable because it has had a shorter residence time. Consequently, this water will usually contain higher concentrations of pesticides than deeper groundwater where the residence time has been longer and there has been more opportunity for pesticides to break down and/or be diluted with water that is not contaminated with pesticide residues. Both these approaches are being used in Europe.

The first approach, used in the Dutch registration process, is to average the concentration of the pesticide of interest in the top one metre below the water table (Tiktak et al., 2000). The second approach, recommended by the Forum for the Coordination of Pesticide Fate Models And Their Use (FOCUS) for use in the EU pesticide registration process, is to estimate the flux (movement) of the pesticide and water across the water table over a fixed interval of time (FOCUS, 2000). Both these approaches estimate pesticide concentrations in shallow groundwater and, therefore presumably, vulnerable groundwater drinking sources. Regulating pesticides based on concentrations estimated in shallow groundwater is considered to be protective of groundwater drinking sources which are usually drawn from deeper groundwater (J.Boesten, pers. comm.).

The PMRA is currently following the depth averaging approach in shallow groundwater for its Level 1 estimates. However, the PMRA is evaluating the flux averaging method advocated by FOCUS and may adopt this approach if it is found to be more appropriate than depth averaging.

The PMRA recognizes that at some locations, pesticide concentrations in groundwater may be lower than the model estimates. This is especially true of the initial screening levels as the input parameters used for modelling are often conservative. In addition, although users could apply a pesticide at the highest use rate and frequency, typical rates and frequencies may be lower than the values used in the model. Moreover, while not required by the pesticide label, users may engage in practices which may reduce pesticide leaching, such as not applying the product when weather conditions favour leaching. Thus, where typical application practices are lower than label maximum or where soil properties and site characteristics are less conducive to leaching, actual concentrations in groundwater may be significantly lower than the values for the sites and conditions modelled.

3.4 The use of monitoring data

In any drinking water assessment, the Agency makes use of available monitoring data pertinent to the pesticide under review. Valid monitoring data would be considered preferable to pesticide concentration estimates in drinking water generated using water models; however, for new chemicals, monitoring data will usually be unavailable. In such cases, if monitoring data would be essential for conducting a refined exposure assessment, it would be requested that the registrant provide monitoring data that are generated under controlled study conditions. The majority of available monitoring studies and data are likely to be for pesticide products that have already been on the market for some time. These monitoring studies are expected to vary considerably as to the quality and quantity of available data and with the amount of contextual information described below.

In evaluating, characterizing and interpreting water monitoring data, the PMRA attempts to collect as much information as is readily available on the design of the studies. This would include information on how the samples were collected and analysed, why they were collected, and where and when they were collected. In evaluating the quality of monitoring data, the Agency must consider the spatial and temporal conditions under which the monitoring was conducted. Spatial considerations include whether the data originates from areas of pesticide use and temporal considerations would include information relating the timing of pesticide application to timing of sampling. Other ancillary data that are important include accurate weather data, hydrological data (size and type of receiving water, depth of groundwater), geochemical and geophysical characteristics (topography, soil characterisation).

The level of variability and uncertainty associated with existing monitoring data in Canada means that the use of these data to predict EECs can be challenging. Reported concentrations may vary considerably from one area to the next. Without having specific information on the history of the use of the pesticide in the sampled area, it is very difficult to fully understand the reasons for these differences. Further, the PMRA is not always able to discern whether samples were taken from potential drinking water sources or waters that would be representative of such drinking water sources.

Interpreting the results of studies which include a large number of samples with no residues (i.e., "non-detects") poses additional difficulties. Non-detects can indicate that the pesticide of concern is not reaching the drinking water source. However, non-detects can also result when the samples are taken from areas where the pesticide is not applied or at times when the pesticide is not being used. Limitations of analytical methods may also result in non-detects (i.e., the pesticide may be present in the water at concentrations that are less than the limit of detection for the analytical method or the analytical method may not be appropriate for certain compounds). For these reasons, the Agency must consider such information in interpreting non-detects in monitoring data sets. The PMRA often lacks data to verify that reported "non-detects" were in actual areas of pesticide use and therefore has difficulty concluding that the pesticide, when used, is not in fact reaching water frequently enough to be of concern. As a result of the above, the PMRA will assign a value equivalent to half the limit of detection (LOD) to non-detects in datasets where it is deemed appropriate. This may include (1) non-detects in a dataset that contains at least one detection or (2) a dataset where there are no detections but it is determined that the particular active ingredient may be used within the watershed sampled and that there is a potential for the active ingredient to contaminate water bodies. This approach has been used by the U.S. EPA during their re-evaluation of several pesticides, including diazinon and triallate (http://www.epa.gov/pesticides/op/diazinon/water.pdf, http://www.epa.gov/oppsrrd1/reregistration/triallate/triallate.efed.red.pdf). This approach is protective of drinking water sources which may be receiving pesticide residues in quantities too small to be measured.

Despite the challenge of analysing and interpreting these data, the PMRA will use the results of monitoring data, when valid data are available, to make decisions with respect to the expected concentration of a pesticide in drinking water. Monitoring data that are limited with respect to temporal and spatial information is always considered as part of the overall risk assessment, but the weight given to these data will vary depending on the circumstances. For instance, if monitoring data of marginal quality consistently yield estimated concentrations that are higher than those predicted by the screening models, then the weight given to the monitoring data would be higher than if the monitoring data yielded a series of non-detections.

Overall there is a paucity of adequate monitoring data for pesticides in drinking water sources in Canada, and the PMRA risk assessments would be strengthened by additional monitoring programs. As such, the Agency is working on a number of levels to fill in these gaps and acquire more high quality data on pesticide concentrations in drinking water sources. Cooperation with other jurisdictions within the federal, provincial, territorial and municipal levels of government will be important in this process.

3.5 Factoring in water treatment

The degree to which drinking water is treated prior to consumption varies greatly in Canada. Owners of private wells often consume untreated water. Many municipalities employ at least a basic system of coagulation, filtration and disinfection, some other communities may have additional treatment steps such as activated carbon adsorption. In addition Canadians may further treat their drinking water using commercially available water purification systems designed for household use. It is known that different treatment systems remove certain classes of pesticides more effectively than others but water treatment technologies currently in use in most Canadian municipalities usually cannot remove pesticides very effectively. Due to the wide variety in the degree of treatment as well as the differences in the degree of removal of pesticides by the differing treatment technologies, the PMRA has opted not to factor in pesticide removal by water treatment in its drinking water assessment. Therefore estimated pesticide concentrations generated for use in dietary risk assessments will not consider the effects from water treatment.

While the removal of pesticides via treatment will not be factored into the drinking water assessment, it should be noted that water treatment has the potential to create toxic breakdown products which may persist in treated drinking water. For instance, the weight of evidence has shown that chlorination of organophosphate compounds can lead to the formation of oxon breakdown products which can be significantly more toxic than the parent compound. It is currently unknown to what extent oxon formation occurs and to what degree these compounds persist after they have been formed (U.S. EPA, 2001). The PMRA will be examining the question of toxic metabolite formation as a result of water treatment and will take appropriate action as more information becomes available.

4.0 How EECs are incorporated into a risk assessment

Once estimates of pesticide concentrations in drinking water have been generated by the Agency, the model-generated concentration estimates for a pesticide in ground and surface water are compared with the Drinking Water Level Of Comparison (DWLOC)[5]. If the model-estimated concentrations in groundwater and surface water are less than the DWLOC, the PMRA concludes with reasonable certainty that residues of the pesticide in drinking water from present uses do not contribute towards an aggregate level of

[5] The DWLOC is the highest concentration of a pesticide in drinking water that would be acceptable considering the estimated exposure to that pesticide from other sources (i.e., food and residential uses).

exposure (food and water) that exceeds a risk level of concern. Details of this process can be obtained in the PMRA draft document entitled General Principles For Performing Aggregate Exposure And Risk Assessments (Pest Management Regulatory Agency, 2002).

5.0 Future directions

It must be emphasised that the process of estimating pesticide concentrations in Canadian drinking water sources is evolving. At the present time, the Agency is formalising its Level 1 screening estimates for both new pesticides and those undergoing re-evaluation. A formalised approach to refine estimates in the event that a chemical does not pass the Level 1 screening has yet to be completed. In the interim, refined estimates will be conducted on a case-by-case basis drawing on the expertise of Agency modellers, experts in the field of environmental fate and chemistry, as well as experts in the field of human exposure and toxicology.

The Agency is conducting sensitivity analysis on the surface and ground water models in order to ascertain which factors are most important in determining the expected pesticide concentrations in drinking water sources. The information obtained from the sensitivity analysis will aid in the development of more refined modelling techniques for the higher levels of the analysis.

The Agency will be updating our current agricultural scenarios and will create new ones as needed.

The Agency will continue with its attempt to identify a Canadian equivalent to the Shipman reservoir for use with the surface water models.

The Agency will actively pursue opportunities to develop high quality national scale monitoring data with the provinces, territories, municipalities as well as other federal departments.

The Agency approach to risk assessment is evolving from a deterministic approach to a probabilistic one. Therefore, the PMRA will examine how the current outputs from the water models can be adapted for incorporation into a probabilistic assessment of pesticide exposure.

The Agency will continue to monitor and evaluate new and evolving approaches in other jurisdictions, such as the U.S. EPA and the EU, in an effort to keep current with this branch of science.

List of abbreviations

ADI	acceptable daily intake
DEEM®	Dietary Exposure Evaluation Model®
DWLOC	drinking water level of comparison
EU	European Union
EEC	expected environmental concentration
EXAMS	Exposure Analysis Modelling System
EXPRES	Expert system for Pesticide Regulatory Evaluation Simulations
FIFRA	*Federal Insecticide, Fungicide, and Rodenticide Act*
FOCUS	Forum for the Co-ordination of Pesticide Fate Models and their Use
GENEEC	Generic Estimated Environmental Concentration Model
LEACHM	Leaching Estimation And Chemistry Model
LOD	limit of detection
MUD	Municipal Use Database
PCPA	*Pest Control Products Act*
PRZM	Pesticide Root Zone Model
PMRA	Pest Management Regulatory Agency
U.S. EPA	United States Environmental Protection Agency

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